EDGE SMOOTHING:

Let t=0 be the time edge is encountered
Let t<0 be before the edge
Let t>0 be following the edge
Let In(m) be the value of intensity bit n at time m

I3(-3) = I3 of old sprite
I2(-3) = I2 of old sprite
I1(-3) = I1 of old sprite
I0(-3) = I0 of old sprite

I3(-2) = I3(-3)
$I2(-2) = I2(-3)+\overline{I3(-3)}$
I1(-2) = I1 of old sprite
I0(-2) = I0 of old sprite

I3(-1) = 1
I2(-1) = I3(-2)
I1(-1) = I1 of old sprite
I0(-1) = I0 of old sprite

I3(0) = 1
I2(0) = 1
I1(0) = I1 of old sprite
I0(0) = I0 of old sprite

I3(1) = 1
I2(1) = I3(2)
I1(1) = I1 of new sprite
I0(1) = I0 of new sprite

I3(2) = I3(3)
$I2(2) = I2(3)+\overline{I3(3)}$
I1(2) = I1 of new sprite
I0(2) = I0 of new sprite

I3(3) = I3 of new sprite
I2(3) = I2 of new sprite
I1(3) = I1 of new sprite
I0(3) = I0 of new sprite

REAL TIME CLOCK

```
                 +----+ NTSC
             +-->| /4 |-----+
+-------------+  |   +----+     |   +----+
| COLOR_CLOCK |--+          +-->| /9 |--> RTC
+-------------+  |   +----+ PAL |   +----+
             +-->| /5 |-----+
                 +----+
```

```
      NTSC RTC = 3.579545 MHz /36   = 99.431806 KHz ; 10.05714 us
(+0.5714%)
      PAL RTC  = 4.43361875 MHz /45 = 98.534878 KHz ; 10.14869 us
(+1.4869%)
                                                      --------
                                           PAL slower by 0.9155%
```

```
                   +-----+ NTSC
               +-->| /72 |-----+
+---------------+  |   +-----+     |
| COLOR_CLOCK*2 |--+            +--> RTC
+---------------+  |   +-----+ PAL |
               +-->| /89 |-----+
                   +-----+
```

```
      NTSC RTC = 7.15909 MHz /72   = 99.431806 KHz ; 10.057140 us
(+0.57140%)
      PAL RTC  = 8.8672375 MHz /89 = 99.6319 KHz   ; 10.036948 us
(+0.36948%)
                                                      ---------
                                           PAL faster by 0.20192%
```

PROGRAMMING VIVIAN:

```
      BLOCK = ADDRESS[23,14]
      BLKADRS = ADDRESS[13,0]

Read/Write BLOCK BLKADRS DATA MODE COMMENT
---------- ----- ------- ---- ---- --------------------------------
----
    R      %         %   %    %   Normal read cycle.
    W    > 0         %   %   NORM Normal write cycle.
    W      0         %  mode  %   Set mode.
      W       l      %     p   MAP  Map LOGICAL_BLOCK(l) to
                                        PHYSICAL_BLOCK(p).
      W       c      %     p   CONF Configure PHYSICAL_BLOCK(p)
per
                                        configuration word c.
      W       t      %     p   TIME Set timing for
PHYSICAL_BLOCK(p)
```

per timing word t.

W l a % COPY DMA copy contents of READ_ONLY_BLOCK

(identified during CONF) address =

a to LOGICAL_BLOCK(l) address = a.

No other writes allowed while in

copy mode. CPU data bus tristated

and CPU acts as DMA controller.

```
MEMORY FETCH MACHINE:

  RAS OR NOT MEM_REQ
  +-----------------+
  |             |
  |   +-------+   |                +-------+ NOT NEW_RA +-------+
  |   |     O---+------------------->|    |----------->|        |
  +---->| IDLE0  | NEW_RA OR NOT MEM_REQ      |  RAS      |
|  CAS  |
      |     |<---------------------O    |<-----------|        |
      +-------+             +-------+       +-------+
           00                     01

    ___
    RAS+CAS2+SLEEP
  +-----------------+
  |             |    ____ _____
  |   +-------+   |    RAS*CAS2*SLEEP   +-------+
  |   |     |---+------------------->|    |
  +---->| IDLE   |                 |  CAS1     |
      |     |<---------------------|    |
      +-------+             +-------+
           0                      1

    ___
    RAS+CAS1+SLEEP
  +-----------------+
  |             |    ____ _____
  |   +-------+   |    RAS*CAS1*SLEEP   +-------+
  |   |     |o--+------------------->|    |
  +---->| IDLE   |                 |  CAS2     |
      |     |<--------------------o|    |
      +-------+             +-------+
           0                      1


CLOCK = COLOR_CLOCK*2

STATE PROCESS
----- -----------------------
IDLE  RAS = FALSE
      CAS = FALSE
      WAIT = TRUE
      IF RAS OR NOT MEM_REQ,
        GOTO IDLE0
RASPC       RAS = TRUE       ; RAS pre-charge time = 2 pixels
      CAS = FALSE
      WAIT = TRUE
      ADR_BUS = RA
      TEMP_REG = RA
CAS   RAS = TRUE       ; CAS width = 2 pixels
```

```
      CAS = TRUE
      WAIT = FALSE
      ADR_BUS = CA
CASPC RAS = TRUE       ; CAS pre-charge time = 2 pixels
      CAS = FALSE
      IF MEM_REQ AND NOT NEW_RA,
        GOTO CAS
      IF NOT MEM_REQ OR NEW_RA,
        GOTO IDLE

TIMING FOR INTERNAL MODE:


            __       __       __       __       __       __
CLK24_0 ___/  \_____/  \_____/  \_____/  \_____/  \_____/  \_____
           :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :  .  .

      ______ __________________________ _________________ _____
RA    ______X__________________________X_________________X_____
           :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :  .  .

      ______ _________________ ________ _________________
CA    ______X_________________X________X_________________X
           :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :  .  .
           __                          __
NEWROW     ____/  \_______________________/
\________________________
           :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :  .  .

MEMREQ     ___|
             ________                   ________
LATCHRA ______/        \_________________/        \_______________
             ________                   ________
CHARGE  ______/        \_________________/        \_______________
      ______       ____________________       _________________
CHRAS       \_____/                    \_____/
      ______          _________________          ______________
CHARGED       \________/                 \________/
             _____                      _____
RAS   ______/     \____________________/     \_________________
          ___________       __       ___________       __
CAS   ___/           \_____/  \_____/           \_____/  \_____
           :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :  .  .
             __                __
NEW_RA _____/  \______________/  \________________________
           :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :  .  .
            _________________          ________________
ENBCAS ____/                 \________/
                                 _____
WAIT   _________________________/     \___________________
                                 _____
DISRAS _________________________/     \___________________
___   _____                      _____
RAS        \____________________/     \__________________/
           :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :
___   ________       __       ___________       __
CAS           \_____/  \_____/           \_____/  \_____/
```

```
           :  .  .  :  .  .  :  .  .  :  .  .  :  .  .  :  .  .


TIMING FOR ONE FETCH AND NO ROW ADDRESS CHANGE:

      __    __    __    __    __    __    __    __    __
CLOCK   \__/  \__/  \__/  \__/  \__/  \__/  \__/  \__/  \__
            ______________________________________
REQ   _____/                                      \_____
      ______ ___________ ________ _________________ ____
ADRS  ______X___________X________X_________________X____
      ___________       __       ___________       _____
WAIT             \_____/  \_____/           \_____/
____  ________              _____________________________
RAS2          \___________/
              |                 |1 |  2  |        |1 |
____  _________________             _____             __
RAS1                   \___________/     \___________/
      |  2  |                 |1 |  2  |        |1 |
       _______|                 | _______|        | ____
NEW_RA        \__________________/       \_________/
            |1 |              |              |
____  ___________|  2   ____________________      |_____
CAS1         \_____/        |           \_____/
                   |1 |     |          |
_____ ______________   |________________________  |_____
DSTB1           \__/  |     |              \__/
____  ____________________|  2  |_______________________
CAS2                  \_____/
_____ _______________________   |_______________________
DSTB2                    \__/
___   ___________       __       ________       ________
CAS          \_____/  \_____/        \_____/
         __    __    __    __    __    __    __    __
CLOCK __/  \__/  \__/  \__/  \__/  \__/  \__/  \__/  \__
____  ______________    _____    ___________    ________
DSTB            \__/     \__/           \__/
```

```
PERCEPT PARAMETER FETCH MACHINE:

      NOT PARM_REQ
   +-----------------+
   |  +-------+    |         +-------+
   |  |     |----+           |     |
   +--->| IDLE    |  PARM_REQ      | LINK0    |<---+<-----+
      |     |--------------->||   |          |
      +-------+        +-------+    |        |
          A              |   |      |        |
          |       NOT WAIT |    | WAIT |     |
          |              |   +------+        |
          |              V             |
      +-------+        +-------+       |
      |     |          |     |         |
      |     |          | LINK1     |<---+         |
      |     |          |     |    | SKIP |
      +-------+        +-------+    | AND  |
          A              |   |      | NOT  |
          |       NOT SKIP |    | WAIT | WAIT |
          |         AND        |   +------+------+
          |       NOT WAIT V
      +-------+        +-------+
      |     |          |     |
      |CLEANUP|        | DISP0     |<---+
      |     |          |     |    |
      +-------+        +-------+    |
            A                 |   |      |
     WAIT     |          NOT WAIT |   | WAIT |
   +------+   | NOT WAIT       |   +------+
   |    |   |                  V
   |  +-------+        +-------+
   |  |     |          |     |
   +--->| LINK5  |          | LINK2     |<---+
      |     |          |     |    |
      +-------+        +-------+    |
            A                 |   |      |
     WAIT     |         NOT WAIT |   | WAIT |
   +------+   | NOT WAIT       |   +------+
   |    |   |                  V
   |  +-------+        +-------+
   |  |     |          |     |
   +--->| LINK4  |          | LINK3     |<---+
      |     |          |     |    |
      +-------+        +-------+    |
            A                 |   |      |
     WAIT     |         NOT WAIT |   | WAIT |
   +------+   | NOT WAIT       |   +------+
   |    |   |                  V
   |  +-------+      NOT WAIT      +-------+
   |  |     |<--------------||
```

```
+--->| DISP2  |        WAIT    | DISP1    |<---+
   |      |        +----|   |     |
   +--------+      |  +--------+    |
                   +-----------------+
```

```
EQUATES:

DXPOS EQU   DAT_BUS[9,0]
DXOFF EQU   DAT_BUS[8,0]
DYPOS EQU   DAT_BUS[9,0]
DYOFF EQU   DAT_BUS[8,0]
DZPOS EQU   DAT_BUS[8,0]
DZOFF EQU   DAT_BUS[7,0]
DHGT  EQU   DAT_BUS[15,8]
DLINK EQU   DAT_BUS[13,0]
DDISP EQU   DAT_BUS[13,0]
DDATA EQU   DAT_BUS[13,0]
ALINK EQU   MEM_ADR[13,0]
PC    EQU   MEM_ADR[13,0]


STATE       ADR_BUS     DAT_BUS     PROCESS     ADDER PERCEPT_DATA
(STROBE)
----- -------     -------     ------- -----     ---------------------
IDLE              MEM_REQ = PARM_REQ
                  ALINK = LINK(P)
                  IF NOT PARM_REQ,
                    GOTO IDLE

LINK0 ALINK DYOFF ALINK = LINK(P)
                  Y = DYOFF
                  FLAG = SKIP(P)
                        ADDA = LINK(P)    ; if last link this P
                        ADDB[1,0] = 1     ; was skip, PC = LINK+5
                        ADDB[2] = SKIP(P) ; else, PC = LINK+1
                        ADDB[13,3] = 0
                        PC = ADD

                  IF WAIT,
                    GOTO LINK0

LINK1 PC    DDISP       ADDA = Y
             OR         ADDB = -LC
            DLINK       Y = ADD
                  SKIP(P) = DSKIP
                  LINK(P) = DLINK

                  IF WAIT,
                    GOTO LINK1

                  IF FLAG AND NOT WAIT,
                    GOTO LINK0

DISP0 DISP  DYPOS
                  IF WAIT,
                    GOTO DISP0
```

```
LINK2 LINK+2      DHGT        ADDA = Y
            DZOFF       ADDB = YPOS
                        Y = ADD
                  FLAG = SIGN(Y)

                  IF WAIT,
                    GOTO LINK2

LINK3 LINK+3      DDATA       ADDA = Y    PY (YS)
                        ADDB = HGT
                        IF FLAG,
                          HGT = ADD
                  IF FLAG,
                    PY = 0
                  IF NOT FLAG,
                    PY = NEGPOLY(Y)

                  IF WAIT,
                    GOTO LINK3

DISP1 DISP+1      DZPOS       ADDB = DATA PHGT (HGTS)
                        IF FLAG,
                          ADDA = 2|Y|
                        IF NOT FLAG,
                          ADDA = 0
                        DATA(P) = ADD
                  IF SIGN(HGT)
                    PHGT = 0
                  IF NOT SIGN(HGT)
                    PHGT = NEGPOLY(ABS(HGT))

                  IF WAIT,
                    GOTO DISP1

DISP2 DISP+2      DXPOS       ADDA = ZPOS
                        ADDB = ZOFF
                        Z = ADD
                        FLAG = SIGN(ADD)

                  IF WAIT,
                    GOTO DISP2

LINK4 LINK+4      DXOFF       ADDA = XPOS ; x=0 is X=-128 in space
                        ADDB = 488
                        X = ADD
                        FLAG = SIGN(ADD)
                  IF FLAG,          PZ (ZS)
                    PZ = 0
                  IF NOT FLAG,
                    PZ = ABS(Z)

                  IF WAIT,
                    GOTO LINK4
```

```
LINK5 LINK+5      DLINK       ADDA = X
                        ADDB = XOFF
                        X = ADD
                        FLAG = SIGN(ADD)
                  SKIP(P) = DSKIP
                  LINK(P) = DLINK

                  IF WAIT,
                    GOTO LINK5

CLEANUP                 IF FLAG,          PX (XS)
                    PX = 0
                  IF NOT FLAG,
                    PX = NEGPOLY(X)

                  GOTO IDLE
```

DERIVATION OF COLOR CHARTS:

1. I PLOTTED ALL POSSIBLE COMBINATIONS OF PHASERS (IE, 16X31)

2. I THREW OUT ALL COMBINATIONS WHICH EXCEEDED THE LIMITS

$$0 =< R,G,B =< 23.9$$

3. I FOUND THE MAXIMUM SATURATED R, G & B POINTS AND DREW LINES FROM THE ORIGIN TO THOSE POINTS TO DIVIDE THE GRAPH INTO THREE REGIONS

   AN R TO G REGION,
   A G TO B REGION &
   A B TO R REGION.

4. I ASSIGNED MINIMUM REQUIRED LUMINANCE FOR EACH SURVIVING POINT

   FOR R TO G REGION

$$P0 = .493*(-.30*R-.59*G)$$
$$P1 = .877*(.70*R-.59*G)$$
$$LUMmin = .30*R+.59*G = -P0/.493$$

   FOR G TO B REGION

$$P0 = .493*(.89*B-.59*G)$$
$$P1 = .877*(-.11*B-.59*G)$$
$$LUMmin = .11*B+.59*G = -P1/.877$$

   FOR B TO R REGION

$$P0 = .493*(-.30*R+.89*B)$$
$$P1 = .877*(.70*R-.11*B)$$
$$LUMmin = .30*R+.11*B = .3782*P0+.5798*P1$$

   IN THE ABOVE CALCULATIONS, 'LUMmin' IS THE LUMINANCE WHICH IS REQUIRED JUST TO SUPPORT THE CHROMINANCE VECTORS WITHOUT ANY ADDED LUMINANCE (IE, FULLY SATURATED CHROMINANCE).

5. I READJUSTED THE MINIMUM LUMINANCE UPWARD FOR POINTS WHICH WERE OVERSATURATED (IE, THE SIGNAL DIPPED BELOW -20IRE)

$$\text{OVERSATURATED SIGNAL} < -20IRE$$
$$LUMmin(+/-)P0, LUMmin(+/-)P1 < -20IRE = -5$$

6. I THREW OUT ALL POINTS WHICH WERE OVERMODUATED (IE, THE SIGNAL

OVERSHOT 120IRE) WITH EVEN THE MINIMUM LUMINANCE

120IRE < OVERMODUATED SIGNAL
29 = 120IRE < LUMmin(+/-)P0,LUMmin(+/-)P1

DERIVATION OF COLOR CHARTS (CONTINUED):

7. I FOUND THE AMOUNT OF PRIMARY COLORS IN EACH POINT AT MINIMUM LUMINANCE

FOR R TO G REGION

```
P0 = .493*(-.30*R-.59*G)
P1 = .877*(.70*R-.59*G)
R = -P0/.493+P1/.877
G = -2.4066*P0-.5798*P1
```

FOR G TO B REGION

```
P0 = .493*(.89*B-.59*G)
P1 = .877*(-.11*B-.59*G)
B = P0/.493-P1/.877
G = -.3782*P0-1.7200*P1
```

FOR B TO R REGION

```
P0 = .493*(-.30*R+.89*B)
P1 = .877*(.70*R-.11*B)
R = .3782*P0+1.7200*P1
B = 2.4066*P0+.5798*P1
```

8. I SOLVED FOR MAXIMUM LUMINANCE FOR EACH POINT BY ADDING DELTA TO ALL THREE COLORS UP TO THE MAXIMUM OF 24 FOR ANY ONE COLOR

FOR R TO G REGION

```
DELTA = SMALLEST{24-R,24-G}
LUMmax = LUMmin+DELTA
```

FOR G TO B REGION

```
DELTA = SMALLEST{24-G,24-B}
LUMmax = LUMmin+DELTA
```

FOR B TO R REGION

```
DELTA = SMALLEST{24-R,24-B}
LUMmax = LUMmin+DELTA
```

9. I READJUSTED THE MAXIMUM LUMINANCE DOWNWARD FOR POINTS WHICH WERE OVERMODULATED (IE, THE SIGNAL OVERSHOT 120IRE)

```
     120IRE < OVERMODUATED SIGNAL
29 = 120IRE < LUMmax(+/-)P0,LUMmax(+/-)P1
```

10. I ENTERED LUMmin AND LUMmax FOR EACH POINT ON THE CHARTS BESIDE EACH POINT.

```
        GENERATION OF VIDEO OUTPUT
                                     +-----+
                                     ! MUX !
                                     +-----+
                        '0000'====4=>!3    !
                        DIM[B,8]==4=>!2    !
                        DIM[7,4]==4=>!1    ! LUMI
                        DIM[3,0]==4=>!0
out!=4====================[3,0]=>H
                                     !     !
H
                        SEL=======2=>!sel  !       +-----+
H
                                     +-----+       !ADDER!
H
              +--------+                           +-----+
H
              !16x5 ROM!                           !     !
H
              +---+----+                 LUM====5=>!a    !
H
              ! F ! 1F !                           !     !
H
              ! E ! 1E ! P1=>H          +-----+    !     !
H
              ! D ! 1D !     H          ! MUX !    !     ! CI
H
              ! C ! 1C !     H          +-----+
!a+b+c!=6=======[9,4]=>H
              ! B ! 1B !   H====I>o==5=>!3    !    !     !
H
              ! A ! 1A !   H H=======5=>!2    !    !     !    CI    IRE
H
              ! 9 ! 19 !   H H==I>o==5=>!1    !    !     ! DEC HEX LEVEL
H
        P0=4=>! 8 ! 18 !==>H=========5=>!0 out!=5=>!b    ! --- --- -----
H
              ! 7 ! 17 !                !     !    !     !  29  1D  +120
H
              ! 6 ! 16 !           H=2=>!sel  !    !     !  24  18  +100
H
              ! 5 ! 0A !           H    +-----+    !     !   0  00     0
H
              ! 4 ! 08 !           H               !     !  -5  3B   -20
H
              ! 3 ! 06 !           H-[0]---------->!c    !
H
              ! 2 ! 04 !           H               +-----+
H
```

```
              ! 1 ! 02 !           H
H
              ! 0 ! 00 !           H
H
              +---+----+           H
H
                                   H
H
        +-------------+            H
H
        !     CTRL    !            H
H
        +-------------+            H
H
        !        state!=2=========>H
H
        ! LUM+P0 = 00 !
H
        ! LUM-P1 = 01 !
H
        ! LUM-P0 = 11 !
H
        ! LUM+P1 = 10 !
H
        +-------------+
H

H<==================================================================H
        H       +-----------------------+
        H       !      1024x6  ROM      !          C     IRE
        H       +-----------------------+        DEC HEX LEVEL
        H       !                       !        --- --- -----
        H       ! A = CI*10**{-LUMI/16* !         39  27  +120
        H       !     LOG[ABS(CI)]}+10  !         34  22  +100
        H       !                       !         10  0A     0
        H       ! B = INT[A-.49] ; CI<0 !          5  05   -20
        H       !   = 10         ; CI=0 !          0  00   -40  (SYNC)
        H       !   = INT[A+.49] ; CI>0 !
        H==10==>!                       !
                ! C = 0  ; B<5          ! C   +-----------+   +-----+
                !   = B  ; 4<B<40       !=6==>! 6 BIT D/A !-->!     !
                !   = 39 ; B>39         !     +-----------+   ! SUM !-->
VIDEO
                !                       !   SYNC & BLANK----->!     !
                +-----------------------+                     +-----+
```

VIDEO OUTPUT ROM PROGRAMMING TABLE

bits 9,4 in HEX (DEC)	bits 3,0 in HEX															
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00 (0)	06	05	05	04	04	03	03	03	02	02	02	02	01	01	01	01
01 (1)	07	06	05	05					02	02	02	02	01	01	01	01
02 (2)	08	07	06	05					03	02	02	02	02	01	01	01
03 (3)	09	08	07	06	TO BE REVISED				03	02	02	02	02	01	01	01
04 (4)	0A	09	07	06					03	03	02	02	02	01	01	01
05 (5)	0B	09	08	07					03	03	02	02	02	01	01	01
06 (6)	0C	0A	09	07	06	05	05	04	03	03	02	02	02	01	01	01
07 (7)	0D	0B	09	08	07	06	05	04	03	03	02	02	02	02	01	01
08 (8)	0E	0C	0A	08	07	06	05	04	04	03	03	02	02	02	01	01
09 (9)	0F	0D	0B	09	07	06	05	04	04	03	03	02	02	02	01	01
0A (10)	10	0D	0B	09	08	07	06	05	04	03	03	02	02	02	01	01
0B (11)	11	0E	0C	0A	08	07	06	05	04	03	03	02	02	02	01	01
0C (12)	12	0F	0C	0A	09	07	06	05	04	03	03	02	02	02	01	01
0D (13)	13	10	0D	0B	09	07	06	05	04	04	03	02	02	02	01	01
0E (14)	14	11	0D	0B	09	08	06	05	04	04	03	02	02	02	01	01
0F (15)	15	11	0E	0C	0A	08	07	05	04	04	03	02	02	02	01	01
10 (16)	16	12	0F	0C	0A	08	07	06	05	04	03	03	02	02	01	01
11 (17)	17	13	0F	0D	0A	09	07	06	05	04	03	03	02	02	01	01
12 (18)	18	14	10	0D	0B	09	07	06	05	04	03	03	02	02	01	01
13 (19)	19	14	11	0E	0B	09	07	06	05	04	03	03	02	02	01	01
14 (20)	1A	15	11	0E	0B	09	08	06	05	04	03	03	02	02	01	01
15 (21)	1B	16	12	0E	0C	0A	08	06	05	04	03	03	02	02	01	01
16 (22)	1C	17	12	0F	0C	0A	08	06	05	04	03	03	02	02	01	01
17 (23)	1D	17	13	0F	0C	0A	08	07	05	04	03	03	02	02	01	01
18 (24)	1E	18	14	10	0D	0A	08	07	05	04	03	03	02	02	01	01
19 (25)	1F	19	14	10	0D	0A	08	07	05	04	04	03	02	02	01	01
1A (26)	20	1A	15	11	0D	0B	09	07	06	04	04	03	02	02	01	01
1B (27)	21	1A	15	11	0D	0B	09	07	06	05	04	03	02	02	01	01
1C (28)	22	1B	16	11	0E	0B	09	07	06	05	04	03	02	02	02	01
1D (29)	23	1C	16	12	0E	0B	09	07	06	05	04	03	02	02	02	01
1E (30)	24	1D	17	12	0F	0C	09	07	06	05	04	03	02	02	02	01
1F (31)	25	1D	17	13	0F	0C	09	08	06	05	04	03	02	02	02	01

VIDEO OUTPUT ROM PROGRAMMING TABLE (CONTINUED)

bits 9,4 in HEX (DEC)	bits 3,0 in HEX															
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
20 (32)	26	1E	18	13	0F	0C	0A	08	06	05	04	03	02	02	02	01
21 (33)	27	1F	19	14	0F	0C	0A	08	06	05	04	03	02	02	02	01
22 (34)	28	20	19	14	10	0D	0A	08	06	05	04	03	02	02	02	01
23 (35)	29	20	1A	14	10	0D	0A	08	06	05	04	03	02	02	02	01
24 (36)	2A	21	1A	15	10	0D	0A	08	06	05	04	03	02	02	02	01
25 (37)	2B	22	1B	15	11	0D	0A	08	06	05	04	03	03	02	02	01
26 (38)	2B	23	1B	16	11	0D	0B	08	07	05	04	03	03	02	02	01
27 (39)	2B	23	1C	16	11	0E	0B	08	07	05	04	03	03	02	02	01
28 (40)	2B	24	1C	16	12	0E	0B	09	07	05	04	03	03	02	02	01
29 (41)	2B	25	1D	17	12	0E	0B	09	07	05	04	03	03	02	02	01
2A (42)	2B	26	1D	17	12	0E	0B	09	07	05	04	03	03	02	02	01
2B (43)	2B	26	1E	18	12	0E	0B	09	07	05	04	03	03	02	02	01
2C (44)	2B	27	1F	18	13	0F	0B	09	07	05	04	03	03	02	02	01
2D (45)	2B	28	1F	18	13	0F	0C	09	07	05	04	03	03	02	02	01
2E (46)	2B	29	20	19	13	0F	0C	09	07	06	04	03	03	02	02	01
2F	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
30	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
31 (-15)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
32 (-14)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
33 (-13)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
34 (-12)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
35 (-11)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
36 (-10)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
37 (-9)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
38 (-8)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
39 (-7)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
3A (-6)	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
3B (-5)	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01
3C (-4)	02	02	02	02	02	01	01	01	01	01	01	01	01	01	01	01
3D (-3)	03	03	03	02	02	02	02	02	01	01	01	01	01	01	01	01
3E (-2)	04	04	03	03	03	02	02	02	02	02	01	01	01	01	01	01
3F (-1)	05	04	04	04	03	03	03	02	02	02	02	01	01	01	01	01

```
        Display prioritization:

          +----------------------------+
          ! wait for next color clock !<------------------------------------
----+
          +----------------------------+
!
          !    clear contour-flag      !
!
          !  set DIM = COLOR = 0000    !
!
          +----------------------------+
!
                        !
!
                        V
!
            ---------------------------
!
           < non-zero data to output ? > --------------------------------
--->+
            ---------------------------  no
!
                        ! yes
!
                        V
!
            --------------------------            +----------+
!
           < self-contouring sprite ? > ---------> ! update Z !
!
            --------------------------  yes       +----------+
!
                        ! no                           !
!
                        !                              V
!
                        !                   --------------------------
!
                        !                  < closest to screen of all >
!
                        !                  < contours in this block ? > -
--->+
                        !                   --------------------------
no    !
                        !                              ! yes
!
                        !         +----------+         V
!
```

```
                        +<------- ! set flag ! <--------+
    !
                        !         +-----------+          !
    !
                        V                                ! yes
    !
                  ------------                  ---------------------
    !
                 < flag set ? > ------------> < master's flag set ? > ---
    --->+
                  ------------  no              ---------------------  no
    !
                        ! yes
    !
                        V
    !
             -----------------------
    !
            < self-profile sprite ? > ------------------+
    !
             -----------------------  yes                !
    !
                        ! no                             !
    !
                        V         +-----------+          V
    !
                        +<------- ! set flag ! <--------+
    !
                        !         +-----------+          !
    !
                        V                                ! yes
    !
                  ------------                  ---------------------
    !
                 < flag set ? > ------------> < master's flag set ? > ---
    --->+
                  ------------  no              ---------------------  no
    !
                        ! yes
    !
                        V
    !
            --------------------------          +-----------------+
    !
           < is sprite a dim sprite ? > --------->! set DIM = data !------
    --->+
            --------------------------  yes      +-----------------+
    !
                        ! no
    !
                        V
    !
           ----------------------------
    !
```

```
          < is sprite a color sprite ? > --------------------------------
--->+
           ----------------------------  no
!
                        ! yes
!
                        V
!
             -------------------------
!
          <  lowest numbered color  >         +-------------------+
!
          < percept in this block ? > ------->! set COLOR = data !-----
--->+
             -------------------------  yes     +-------------------+
!
                        ! no
!
                        +-------------------------------------------------
--->+
```

ENGINEERING DETAIL - ALGORITHM FOR GENERATING YAW:

YAW	FACT1	FACT2	FACT3	FACT4	dz	dx
0	-	-	-	-	0	1
1	4	5	4	4	4	80
2	2	3	2	3	4	24
3	2	2	2	2	4	16
4	1	2	1	1	4	10
5	1	1	1	1	4	8
6	0	1	0	1	4	6
7	0	1	0	0	4	5
8	0	0	0	0	4	4
9	0	1	0	0	5	4
A	0	1	0	1	6	4
B	1	1	1	1	8	4
C	1	2	1	1	10	4
D	2	2	2	2	16	4
E	2	3	2	3	24	4
F	4	5	4	4	80	4

yaw angle = arctan(dz/dx)

The basic idea here is as follows:

For yaw < 45 degrees, when x has incremented through 2^FACTn pixels, z increments/decrements by 1. This happens for 'n' = 1, 2, 3, & 4 successively for as many repetitions as the length of the data will permit.

For yaw >= 45 degrees, as x increments by one for each pixel, z increments/decrements by 2^FACTn. This happens for 'n' = 1, 2, 3, & 4 successively for as many repetitions as the length of the data will permit.

During the generation of the present line, the initial z value is incremented/decremented PINC times to arrive at the initial z value for the next line.

The reasoning behind the '2^FACTn' increment/decrement instead of simply adding or subtracting a binary is that a power-of-two up/down counter is smaller than an adder. As can be seen, it still yields reasonably usable and accurate values of angle if four intervals are used.

A NIBBLE BINARY TO POLYCODE CONVERTER

Let:

'Bn' be the 'n'th bit of the binary number 'B' and
'Pn' be the 'n'th bit of the polycode number 'P'.

Objective: Convert B to P

```
    TRUTH TABLES                  MAPS

  B     P    Hex  P3:         B3         P2:         B3
----  ----   ---             ----                   ----
0000  0000  0         0  0  0  0             0  0  1  1
0001  0001  1
0010  0011  2         0  0  1  1 |     0  1  1  0 |
  0011     0111  3                     | B0                     | B0
  0100     1111  4         | 1  1  1  0 |   | 1  0  0  0 |
  0101     1110  5     B2 |              B2 |
  0110     1101  6         | 1  1  0  1            | 1  1  1  0
  0111     1010  7              ----                   ----
  1000     0101  8               B1                B1
  1001     1011  9
  1010     0110  A     P1:          B3          P0:          B3
  1011     1100  B                 ----                   ----
  1100     1001  C          0  1  1  0             0  1  0  1
  1101     0010  D
  1110     0100  E          0  1  0  1 |     1  1  0  1 |
  1111     1000  F                     | B0                     | B0
                    | 1  1  0  1 |   | 0  0  0  0 |
                   B2 |              B2 |
                    | 1  0  0  0          | 1  1  0  1
                         ----                   ----
                          B1                B1

  /P3 = /B3*/B2+/B2*/B0+B3*B1*/B0+B3*B2*/B1*B0
  /P2 = /B3*/B2*/B0+/B2*/B1*B0+B2*B1*B0+B3*B2*/B1
/P1 = /B3*/B2*/B1+B3*/B1*/B0+B3*B1*B0+B2*B1*/B0
/P0 = /B3*/B2*/B1*/B0+B3*B1+B2*B0
```

DYNAMIC 4-BIT PRESETTABLE POLYCODE COUNTER WITH TERMINAL COUNT TO ZERO

```
       P3     /P2            P1        /P0
      |          |             |         |
-------|[---------*-|[---------*-|[---------*-|[
      |          |             |         |
--------|--------*---|------------|--------+   |
----*---|--------|---|--------+   |        |   |
    |   *-   -+  |   *-   -+  |   *-   -+  |   *-   -+

               +------__--------*-- Out
               |      |         |
Rfresh --------|------+         |
               |                |
  Data ---__---*  R|-*   +--|R  |
          |    |  |  |\ /    |  | =
  Load ---+    |  *--+ X     *--+
               |  |   / \    |
    In ---__---*-|[--+   *--|[
          |       |
 Shift ---+       +--------- Out'
```